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New records and update on the geographic distribution of *Lontra longicaudis* (Olfers, 1818) (Carnivora: Mustelidae) in Seasonally Dry Tropical Forests of northeastern Brazil

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Abstract. We confirmed occurrences of *Lontra longicaudis* (Olfers, 1818) in Seasonally Dry Tropical Forests (Caatinga) of 10 river basins in northeastern Brazil, reporting the first records of the species in five of them. The species was not found in river basins totally inserted in Caatinga, nor where Caatinga borders Cerrado (Piauí state), indicating a gap in the species distribution. We report the first otter occurrence in Piauí, in the Cerrado biome of the southern part of the state. The relevance of these results for Neotropical Otter conservation is discussed, and an update of the species distribution map is proposed.

Key words. Caatinga; semi-arid; Lutrinae; Near Threatened species; geographic distribution; conservation; occurrence

Neotropical Otter, *Lontra longicaudis* (Olfers, 1818), is one of the least studied species of the subfamily Lutrinae (Mustelidae) because of its elusive behaviour and consequent low detectability in natural environments (Rosas 2004). Although the species is described as widespread, occurring originally from Mexico to Uruguay (Kruuk 2006), its geographical distribution is poorly known in some regions, such as in northeastern Brazil, which until recently appeared as a gap in *L. longicaudis* distribution maps (Eisenberg & Redford 1999; Emmons & Feer 1999; Larivière 1999; Kruuk 2006). Recent studies have reported the occurrence of *L. longicaudis* in some localities of northeastern Brazil, including the states of Bahia (BA) (Souto 2012), Sergipe (SE) (Astúa et al. 2010; Dantas & Donato 2011; Mendonça & Mendonça 2012; Dias & Bocchiglieri 2016), Alagoas (AL) (Fernandes 2003), Pernambuco (PE) (Astúa et al. 2010; Feijó & Langguth 2013), Paraíba (PB) (Astúa et al. 2010; Feijó & Langguth 2013; Toledo et al. 2014), Rio Grande do Norte (RN) (Laurentino & Sousa 2014), and Maranhão (MA) (Mesquita & Meneses 2015). These reports indicate that the aforementioned gap was not due to the actual absence of the species, but to a lack of studies and adequate sampling in the region.

Records of *L. longicaudis* in northeastern Brazil are mostly restricted to Atlantic Forest and its associated ecosystems. No record was reported in Ceará and Piauí, which are states mostly covered by a Seasonally Dry Tropical Forests biome, the Caatinga. This biome has not been considered in the species geographical distribution (Rodrigues et al. 2013). A single occurrence of this species in Caatinga was reported in São Francisco River (SE), which was the first official record of *L. longicaudis* in this biome (Dias & Bocchiglieri 2016). However, no field inventory to verify the presence of the Neotropical Otter was conducted in the region. All *L. longicaudis* occurrence data in northeastern Brazil are occasional reports or compilations of existing occurrence data, which could be geographically biased towards more populated or better-studied regions.

In a recent study, Rheingantz et al. (2014) estimated a species distribution model for *L. longicaudis* and suggested the expansion of its current distribution to new areas, covering Brazil's Northeast Region, including Caatinga biome. Following recommendations by Rheingantz et al. (2014), and based on existing occurrence data, the distribution map of *L. longicaudis* was updated, and now the entire Brazilian territory is included within its distribution range (IUCN 2015). Although the map is presented as a uniform polygon, Rheingantz et al. (2014) pointed the importance of gathering occurrence data in areas with little information, and recommended that northeastern Brazil be a priority area for future studies; this region represents one of the driest areas within the range of the Neotropical Otter.

Confirming the current distribution of this species, with emphasis on North and Northeast regions, is one of the actions set out in the national action plan for the conservation of otters (ICMBio/MMA 2010). Investigating

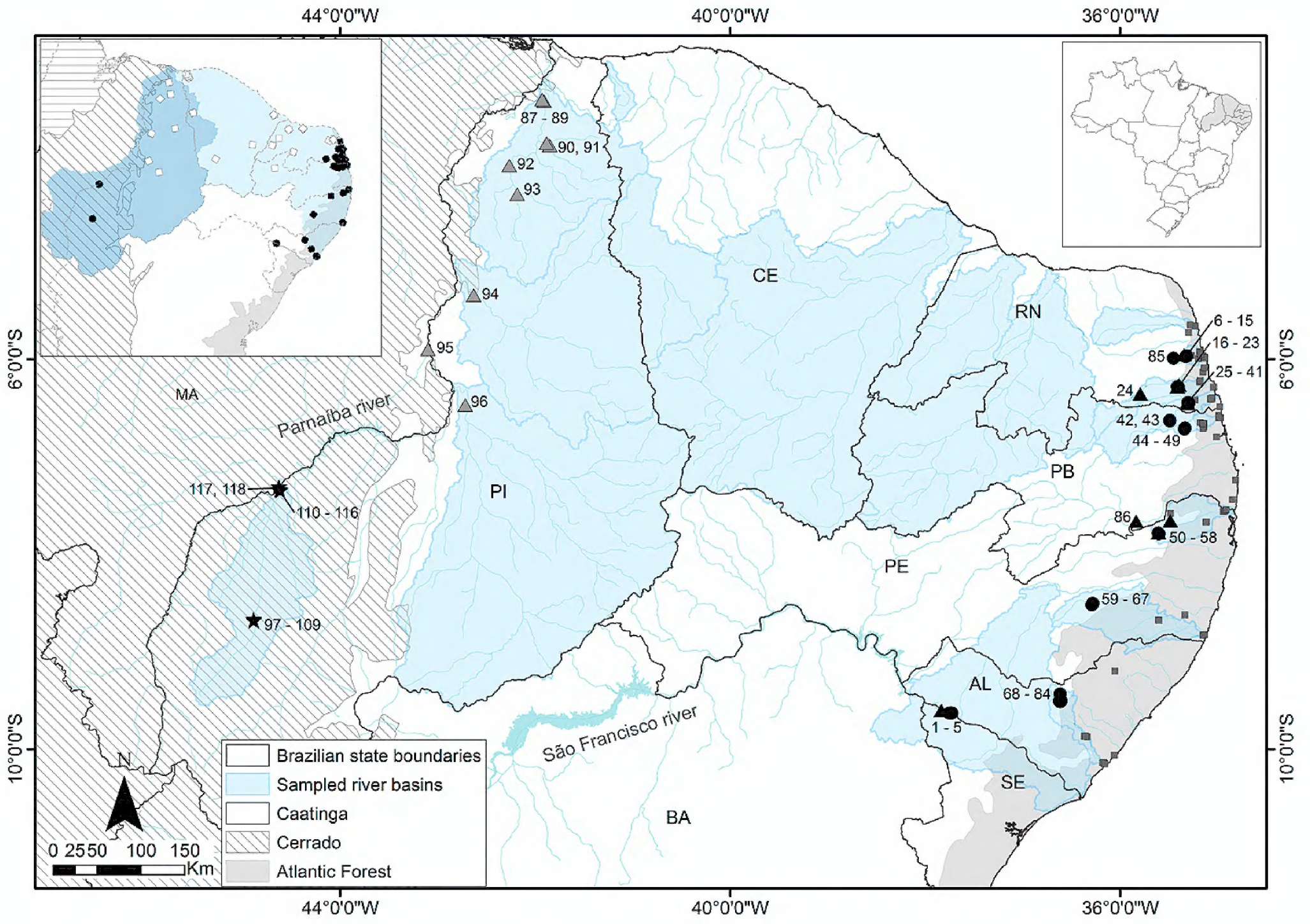

Figure 1. Study area in northeastern Brazil, north of São Francisco River (right inset); Sampled river stretches in Parnaíba (dark blue) and Northeastern Caatinga and Coastal Drainages (light blue) freshwater ecoregions, where current occurrence of otter was confirmed - indicated by black squares, or not confirmed - indicated by white squares (left inset); The main map shows records of *Lontra longicaudis* in Caatinga of northeastern Brazil: signs and camera trap records (black dots), records from interviews (black triangles – current; grey triangles – historical). Black stars indicate first records of *Lontra longicaudis* in Piauí state. Numbers next to the records are identification labels (Record ID in Table 1). Small gray squares indicate records in Atlantic Forest. Datum WGS1984.

the isolation of otter populations in northeastern Brazil is also necessary for this species' conservation, according to a recent risk assessment of *L. longicaudis* (Rodrigues et al. 2013).

The conservation status of *L. longicaudis* was recently updated from Data Deficient to Near Threatened by the International Union for the Conservation of Nature, because of increasing anthropogenic threats to aquatic and terrestrial environments (Rheingantz & Trinca 2015). The species is also classified as Near Threatened in Brazil, and Vulnerable in the northeastern Atlantic Forest region because of the high level of habitat degradation (Rodrigues et al. 2013). The species' conservation status was not assessed for the Caatinga due to the lack of occurrence data in this biome.

To improve the understanding of *L. longicaudis* distribution in northeastern Brazil, the present study assessed this species' occurrence in Caatinga, a seasonally dry tropical forest in the semi-arid region of Brazil's Northeast.

Field campaigns were planned and conducted in northeastern Brazil, north of the São Francisco River. This area is inserted in two freshwater ecoregions: Parnaíba, and Northeastern Caatinga and Coastal Drainages (NCCD) (Abell 2008). The Parnaíba freshwater ecoregion consists of the Paranaíba River and its tributaries, covering the entire Piauí state and a border region between Piauí and Maranhão, including areas of Caatinga and Cerrado biomes; the NCCD freshwater ecoregion extends between Ceará and Alagoas states, covering several smaller river basins and areas of Atlantic Forest and Caatinga biomes (Figure 1). We used the biome boundaries given by the Brazilian Institute of Geography and Statistics, the same adopted for environmental laws.

In the Caatinga biome, the main focus of our study, low annual rainfall ranges from 240 to 1500 mm, but with 50% of the Caatinga's area receiving less than 750 mm/year (Prado 2003). Additionally, the irregularity of rainfalls is the main characteristic of Caatinga biome, where most of the rainfall is concentrated within a three-month period, with wide annual and interannual variation causing periodic severe droughts (Prado 2003). Even with these droughts, the biome sustains 11.8% of the Brazilian human

population, and has been under increasing anthropic pressure for years (Ribeiro et al. 2015).

We selected 16 river basins with the goal to fill gaps in the species distribution records. Each river basin was sampled at three stretches (lower, middle and upper courses; Figure 1). As an exception, two rivers of Parnaíba ecoregion were sampled at only two stretches, a strategy to maximize the number of sampled rivers in this ecoregion, where most of the records were historical occurrences. Headwaters in Caatinga biome are often intermittent and their surroundings stay completely dry most of the year. In these cases, because otters are semi-aquatic animals, instead of sampling the upper stretches near headwaters, we sampled the upper stretches where a minimal amount of water was maintained throughout the year (i.e., river stretches at least 2 m wide or water ponds less than 1 km apart).

Each river stretch was sampled repeatedly for four days over approximately 5 km, looking for sights or indirect signs of otter presence (dens, tracks, faeces, and latrines). This amounted to an overall sample effort of 725 km, of which 472.5 km were inside the Caatinga biome. Sampled stretches were navigated using a boat with outboard engine (controlled speed ≤ 7 km/h) or kayak, or by walking, depending on navigation conditions. Camera traps were placed near fresh dens, trails or latrines in order to obtain photographic records. Besides the active search, semi-structured interviews were conducted with local people, to gather information about historical and current occurrences. At least six interviews were conducted in each sampled river stretch, totalling 445 interviews. Interview records were only considered when supported by pictures, or by detailed report from more than one interviewee. Occurrences were considered historical when no evidence of this species' presence was recorded for more than 10 years.

The extant presence of *L. longicaudis* in Caatinga biome was recorded in seven of the 16 sampled river basins, all of them inserted in NCCD freshwater ecoregion, as well as in an additional stretch sampled in São Francisco River (Figure 1; Table 1). In addition, otter presence in Caatinga was confirmed in two river basins not included in our sampling effort: upper Jundiaí River (Macaíba, RN), where a dead specimen was found; and upper Paraíba River (Umbuzeiro, PB), based on the interviews. These results show a total of 10 river basins in the Caatinga of northeastern Brazil where the Neotropical otter is present (Figure 1; Table 1). Considering only studies that present geographic coordinates, we report here the first accurate records of the species for five of the 10 river basins: Pium (RN), Jundiaí (RN), Jacu (RN), Curimatau (RN/PB), and Coruripe (AL) (Table 1). Except for São Francisco River, all of the sampled river stretches have an intermittent hydrologic regime, maintaining some

Table 1. Current and historical records of *Lontra longicaudis* in Caatinga of northeastern Brazil, and first records of the species in Piauí state (PI). Record type: S= signs, I= interviews, CT= camera trap records, C= carcass. NCCD= Northeastern Caatinga and Coastal Drainages freshwater ecoregion.

Record ID	Freshwater ecoregion	River basin	River stretch	State	City	Number of records	Record type	Latitude[a]	Longitude[a]	Year
1–5	São Francisco	São Francisco	Lower	AL/SE	Piranhas/Canidé do São Francisco	5	S, I, CT	–09.6282	–037.7544	2015
6–15	NCCD	Pium	Upper	RN	Macaíba/São José de Mipibu	10	S, I	–05.9734	–035.3287	2013
16–23	NCCD	Jacu	Middle	RN	Passagem/Santo Antônio	8	S, I	–06.2813	–035.4131	2013
24	NCCD	Jacu	Upper	RN	São José do Campestre	1	I	–06.3542	–035.7946	2013
25–41	NCCD	Curimatau	Middle	RN	Montanhas	17	S, I, CT	–06.4459	–035.3052	2014
42, 43	NCCD	Curimatau	Upper	PB	Caiçara	2	S, CT	–06.6258	–035.4923	2014
44–49	NCCD	Camaratuba	Upper	PB	Lagoa de Dentro/Curral de Cima	6	S, I, CT	–06.7161	–035.3403	2014
50–58	NCCD	Goiana	Upper	PE	Bom Jardim, São Vicente Ferrer	9	S, I	–07.7815	–035.6088	2015
59–67	NCCD	Una	Upper	PE	Cachoeirinha	9	S, I	–08.5194	–036.2909	2015
68–84	NCCD	Coruripe	Upper	AL	Palmeira dos Índios	17	S, I, C	–09.4310	–036.6153	2015
85	NCCD	Jundiaí	Upper	RN	Macaíba	1	C	–05.9896	–035.4541	2015
86	NCCD	Paraíba	Upper	PB	Umbuzeiro	1	I	–07.6609	–035.8360	2015
87–89	Parnaiba	Longá	Lower	PI	Caxingó	3	I	–03.3535	–041.9092	> 50 yr ago[c]
90, 91	Parnaiba	Longá	Middle	PI	São José do Divino	2	I	–03.8084	–041.8504	≅ 50 yr ago[c]
92, 93	Parnaiba	Longá	Upper	PI	Barras/Batalha, Boa Hora	2	I	–04.0130	–042.2641	≅ 50 yr ago[c]
94	Parnaiba	Poti	Lower	PI	Demerval Lobão	1	I	–05.3426	–042.6295	≅ 50 yr ago[c]
95	Parnaiba	Parnaíba	Middle	PI/MA	Palmeirais/Parnarama	1	I	–05.8979	–043.0976	≅ 50 yr ago[c]
96	Parnaiba	Canindé	Lower	PI	Amarante	2	I	–06.4703	–042.7166	≅ 50 yr ago[c]
97–109	Parnaiba	Uruçui-Preto[b]	Upper	PI	Currais/Baixa Grande do Ribeiro	13	S, I	–08.6798	–044.8844	2014
110–116	Parnaiba	Uruçui-Preto[b]	Lower	PI	Uruçuí	7	S, I, CT	–07.3372	–044.6167	2014
117, 118	Parnaiba	Parnaiba[b]	Upper	PI	Uruçuí	2	S, I	–07.3121	–044.6321	2014

[a] When more than one record were found in a river stretch, we presented geographic coordinates of the record further inside Caatinga biome.
[b] First records of *Lontra longicaudis* in Piauí state, Cerrado biome.
[c] Historical records of *Lontra longicaudis*; no evidence of the species occurrence for more than 10 years

ponds or very little volume and water flow during the dry season.

No current occurrence of *L. longicaudis* was recorded in the Caatinga at Parnaíba freshwater ecoregion, where only historical occurrences of about 50 years ago were mentioned in interviews. Current occurrences of the species in this ecoregion were recorded only in the Cerrado of southern Piauí, by signs, camera trap, and interviews, and these constitute the first documented records of *L. longicaudis* in Piauí state (Figure 1; Table 1). The species was not recorded in river basins fully inserted in Caatinga biome, as was the case in the entire Ceará state. The only exception was a historical record, dating more than 100 years ago, from the upper Poti River basin (Ipueiras, CE). The evidence comes from the folk story of the founding of São José das Lontras (St Joseph of the Otters) district, which has been passed down for generations and was mentioned in interviews. In the story, an otter appeared in the local river at the time of the district's founding, giving the locality its name. As none of the interviewees was alive at that time and, according to the story, none of the local people knew the animal, which was identified by a foreigner, we did not consider it as a reliable historical record of *L. longicaudis*.

Current occurrences of *Lontra longicaudis* were mostly confirmed in multiple occasions, by signs (Figure 2), interviews, and sometimes also by camera trap records (Figure 3; Table 1), indicating that otters are residents or frequent users of these river stretches. Otter signs, especially faeces, are the best evidence of otter presence, since they are quite conspicuous, frequently found on prominent rocks, sandbanks and trunks along riverbanks (Quadros & Monteiro-Filho 2002; Kruuk 2006; Kasper et al. 2008). Furthermore, otter faeces are easily identified by their content and smell, consisting mainly of fish and crustacean remains (Kruuk 2006). A voucher specimen (skull) was collected in April 2015 in the upper stretch of Coruripe River basin (AL), and is deposited in the mammal collection of the Departamento de Zoologia, Universidade Federal de Pernambuco, UFPE 3332.

Our records confirm the presence of *L. longicaudis* in Caatinga biome. All current records of the species, however, are located in river basins divided between both the Caatinga and Atlantic Forest biomes, and most of them in a transition zone between the two biomes. Although current occurrences had been recorded in intermittent river stretches, all of these river basins have some perennial stretches at their lower course. The occurrences further inside the Caatinga biome were recorded in São Francisco river basin, which is the largest river of the region, with the headwaters in the Cerrado of southeastern Brazil and with a perennial hydrologic regime. This indicates that water availability is the main factor limiting otter occurrence in northeastern Brazil.

Neotropical Otter occurs in other seasonally dry tropical forests along its distribution, for instance in Mexico (Gallo Reynoso 1997), Colombia (García-Herrera et al. 2015), and Bolivia (Tarifa et al. 2010). In these regions,

Figure 2. *Lontra longicaudis* faeces in the middle stretch of Pium River, Rio Grande do Norte state.

Figure 3. *Lontra longicaudis* in the lower stretch of Uruçui-Preto River, South of Piauí state.

however, tropical dry forests occur as patches within an environmental mosaic encompassing more humid forests, where perennial rivers arise. The mammalian community within dry forests of the upper Tuichi River (Asariamas, La Paz, Bolivia) consists of species from adjacent humid forests (Ríos-Uzeda et al. 2001). In Mexico, the Neotropical Otter usually occurs in arid and semi-arid regions, but always associated with perennial rivers or rivers that maintain permanent ponds (Gallo Reynoso 1997; Monterrubio-Rico & Charre-Medellín 2014). Caatinga is the only vast continuous area of seasonally dry tropical forest in South America (Santos et al. 2012) and one of the most extensive contiguous areas of tropical dry forest in the world (Miles et al. 2006). It encompasses many rivers that originate from and are totally inserted within this biome; they are intermittent for their entire course.

The ability of otters to survive in semi-arid conditions has been shown for the Eurasian Otter [*Lutra lutra* (Linnaeus, 1758)] in Mediterranean ecosystems (Ruiz-Olmo & Jiménez 2008a). In this region, otters can frequently occur in almost dry rivers, provided that some ponds exist;

this is not directly related to the availability of water itself, but to the availability of prey, which include mostly aquatic species (Ruiz-Olmo et al. 2001; Ruiz-Olmo et al 2007).

Despite the ability to adapt to scarce water conditions, long periods of drought decrease resource availability for otters, especially prey, affecting the species in a medium-term (Ruiz-Olmo & Jiménez 2008a). The reduction in the amount of water during these periods also increases the risks associated with foraging, as the otters need to look for food more frequently in shallow areas or out of water, where semi-aquatic species are weaker competitors than terrestrial species, and become more vulnerable to predation and to becoming roadkill (Ruiz-Olmo et al. 2001; Ruiz-Olmo & Jiménez 2008b). The reliance on ponds also makes them more vulnerable to being harassed and killed by local fishermen (Carrillo-Rubio & Lafón 2004). Survival in unstable and harsh climate environments causes additional ecological stress to the animal (Ruiz-Olmo & Jiménez 2008b), which can be worrying if compounded with normally-tolerated environmental impacts. In these situations, otters can migrate to more stable nearby river basins (Ruiz-Olmo & Jiménez 2008a; Ruiz-Olmo & Jiménez 2008b), which may have been the cause for the absence of otters in Parnaíba freshwater ecoregion in the last 50 years. The Parnaíba River has a perennial hydrologic regime, and most of the sampled tributaries maintain water in many stretches or large ponds throughout the year. Nevertheless, in this region the Caatinga borders the Cerrado, the latter a climatically milder biome, where tributaries of the Parnaíba are perennial and may provide less stressful conditions for the species.

River basins completely inserted in Caatinga are under greater influence of semi-arid climate. Caatinga biome is characterized by periodic severe droughts every few years, with rare events of floods (Krol et al. 2001; Prado 2003). Some of river basins completely inserted in this biome have an artificial perennial hydrologic regime because of large reservoirs that control water flow. However, all of these rivers were originally intermittent in most of their course and dried completely for long periods (Rosa et al. 2003). The lower frequency and pronounced irregularity of rainfall, associated with strong water demand from human populations, can be the limiting factor for the occurrence of otters in river basins entirely inserted in Caatinga. Thus, our results indicate a real gap in the current species distribution at this biome. The existence of such gap is also corroborated by the areas of lesser suitability values in northeastern Brazil, estimated by the previously published species distribution model (Rheingantz et al. 2014).

There is no record of occurrences of *L. longicaudis* in historical faunal surveys of Ceará (Dias da Rocha 1948; Paiva 1973; Mares et al. 1981). One exception was reported by the historian Gomes de Freitas (1972), who stated that the last otters were seen in Vale do Coronzó, Jucá River, a tributary of upper Jaguaribe River. This tributary is within the same Caatinga ecoregion as São José das Lontras district (Ipueiras, CE) where the folk story suggests the possible existence of Neotropical Otters more than a century ago. This is a high-altitude region having a wetter climate. In earlier times, it may have been a refuge for *L. longicaudis* in the Caatinga of Ceará, but now it seems to be absent for a long time. None of the oldest interviewees declared to have seen the species.

Studies to assess factors influencing the occurrence of *L. longicaudis* in northeastern Brazil are the next step to increase knowledge and contribute to this species' conservation in the region. This is especially important in the Caatinga, a highly impacted biome that has been neglected by scientific research and conservation strategies (Santos et al. 2011, Ribeiro et al. 2015). Water, an essential resource for otters, is increasingly scarce and demanded by human population in this biome (Krol et al. 2001). We propose updating the IUCN distribution map of *L. longicaudis* to remove the area of northeastern Brazil where there was no direct or indirect evidence of this species' current presence during our sampling, and where none exists in the literature (Figure 4). The excluded area should include river basins completely inserted in Caatinga and those basins where the Caatinga borders the Cerrado; this includes northwestern Rio Grande do Norte and western Paraiba, the whole of Ceará, and the Caatinga of northern Piaui.

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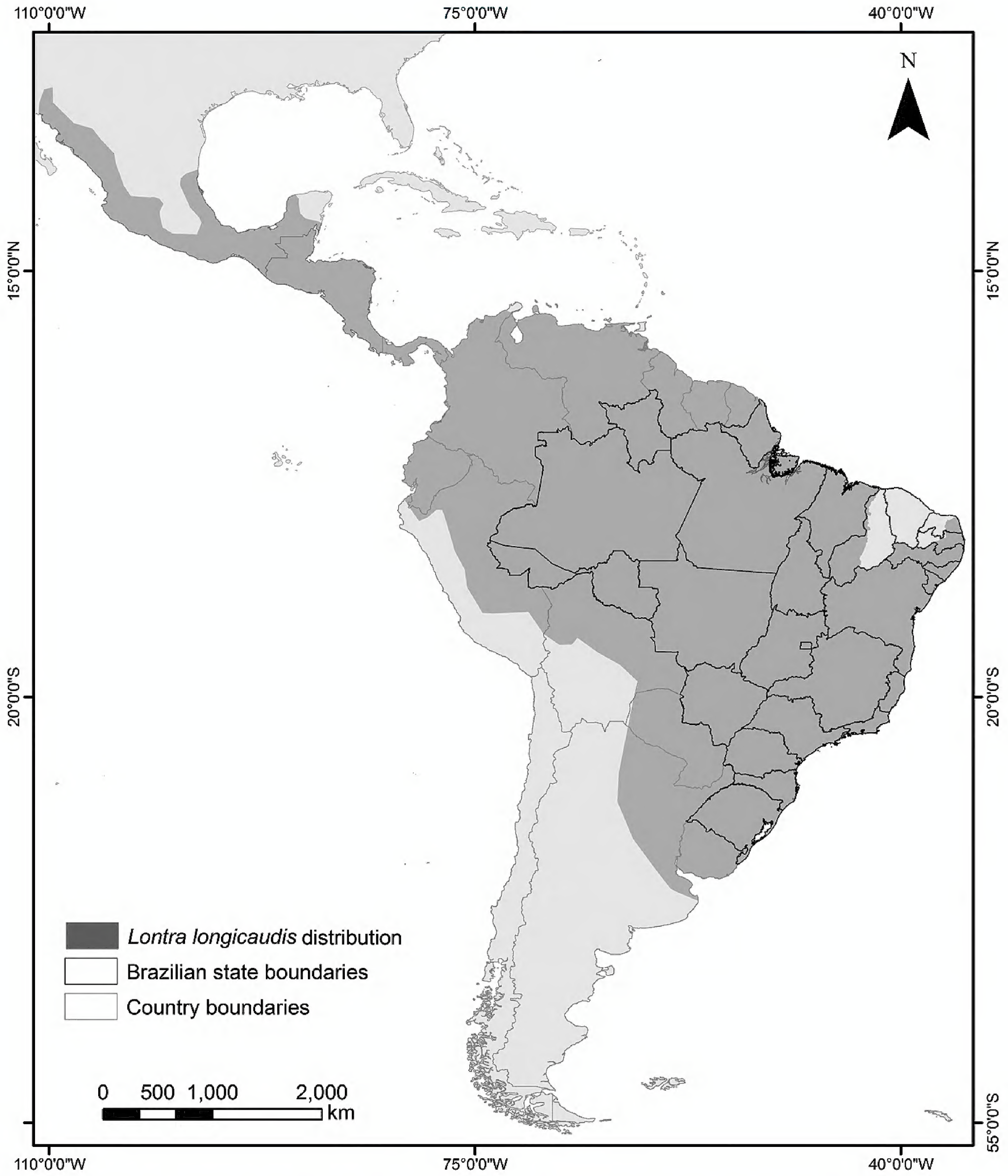

Figure 4. Proposed updated map for *Lontra longicaudis* distribution, to include the gap where no current evidence of the species occurrence was recorded in this study, nor exists in the literature. The excluded area should include the northwestern Rio Grande do Norte and western Paraiba, the whole of Ceará, and the Caatinga of northern Piaui. Distribution map modified from IUCN 2015. Datum WGS1984.

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